Goal-oriented hemodynamic treatment in high-risk surgical patients

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Chapter 4

Costs Related to Preoperative Goal-oriented Hemodynamic Treatment (Tune-up) at the Intensive Care Unit of High-risk Surgical Patients.

"Any new policy that is to be implemented in modern healthcare needs to be considered in terms of its influence on recources. Cardiovascular optimization will initially require more time, more beds, greater skill mix, and suitable postoperative facilities" – O. Boyd.[1]

Introduction

Preoperative goal-oriented hemodynamic treatment (GOHT) of high risk surgical patients has been described to reduce mortality in some studies[2-4] and to improve clinical outcome in others.[5,6] Costs were calculated and analyzed as secondary end point in the context of resource management.[2,7,8] In these studies preoperative investments resulted in a significant reduction in costs. Others found no benefits of preoperatively started GOHT[9-12] and it may be assumed that in these studies costs of this preoperative intervention at the intensive care unit (ICU) surpassed costs of current practice.

In chapter 2 we described an open, randomized, controlled, clinical trial of the efficacy of preoperative GOHT in our hospital on postoperative complications, ICU LOS, hospital LOS and mortality. No firm conclusions could be made regarding the primary end point. With respect to secondary end points, i.e., ICU LOS, hospital LOS and mortality, no relevant differences between the control and protocol (tune-up) group were found either. In Chapter 3 we described the cohort of all high-risk surgical patients eligible for inclusion in the Groningen University Tune-up Study (GUTS). We compared clinical end points, ICU LOS and hospital LOS and mortality of patients participating in the GUTS to patients eligible for the GUTS, but not participating (non-GUTS), mainly because of logistic or personal reasons. Regarding ICU LOS and hospital LOS the non-GUTS patients had a clinical course closely resembling that of the GUTS patients (Chapter 3).

Hospital LOS is the major attributor to hospital costs[13]. GOHT in the GUTS targeted to reduce costs as a secondary end point. We calculated costs of high-risk surgical patients, using a simplified design, assuming that costs generated by ICU LOS and hospital LOS comprise the main part of all costs. First, we compared the costs of both groups of the GUTS as described in Chapter 2. Secondly, we studied patients preoperatively scheduled for postoperative ICU-admission and compared the costs of both groups of the GUTS and the non-GUTS group, i.e. patients that were described in chapter 3 as group A and group B (Chapter 3, figure 1).

Methods

Costs of stay at the ward and the ICU were obtained from data available from national and local resource data management (Centraal Orgaan Tarieven Gezondheidszorg, COTG; College voor Zorgverzekeringen, CVZ; Afdeling Inkoop, University Medical Center Groningen, UMCG; OPERA-codes related to anesthesiologic procedures; Dienst Automatisering & Informatie UMCG). Costs of different issues for calculation of cumulative costs are presented in table 1. Costs of nursing and medical staff are included in the price of one day of stay at the ICU or the ward. Costs of surgical interventions were not included. Follow-up of patients took place till the day of discharge from the hospital.

Table 1. Overview of different costs (Euro).

unit	Hospital and staff				cumulative	
Year	1996		2003/4		1996	2003/4
day at the ward day at the ICU	319 1093		476 1684		319 1093	476 1684
medical device	materials	Staff	materials	staff		
central venous access:						
- CVP-line	35	28	43	40	63	83
- PAC (complete)	88	83	109	119	171	228
- PAC introducer set	53	28	66	40	81	106
epidural catheter	20	50	24	71	70	95
arterial canula	nihil	8	nihil	9	8	9
RBC	22	-	179	-	22	179

ICU, intensive care unit; CVP, central venous pressure; PAC, pulmonary artery catheter; RBC, red blood cell concentrate.

Two analyses were performed. First both subgroups of the GUTS (Control, n = 62, Tune-up, n=65) were compared for costs regarding ICU LOS, hospital LOS and RBC-transfusion requirements. A description of the patients of the GUTS and their surgical procedures can be found in Chapter 2 (Chapter 2, tables 4a and 4b). In this cost analysis special attention was given to RBC-transfusion requirements, since the control patients tended to have more blood loss (Chapter 2, Results) and costs of RBC-transfusion increased tremendously in time (table 1). Data of other transfusion products were not available since thrombocyte transfusion, colloids and fresh frozen plasma were not included in the data base as separate variables. Study protocol related similarities (PAC, arterial line, epidural catheter) of both groups were not taken into account.
Costs of hospital LOS were separated in costs of ICU LOS and costs of LOS at the ward. The preoperative day was calculated as a ward-day for the control patients and as an ICU-day for the tune-up patients. Postoperative ICU-days included the day of ICU-admission after surgery and the day of discharge from the ICU to the ward. The remaining days the patient spent in the hospital were defined as ward-days. The LOS at the ward was calculated as the hospital LOS minus ICU LOS (table 2). Cumulative costs of the control group and the tune-up group were compared.
A second analysis was performed on the costs of GUTS vs. non-GUTS patients postoperatively scheduled for ICU-admission. Measurements for calculations started at the preoperative day; calculation of ward- and ICU-days are similar as described for the first analysis. Differences in costs between GUTS- and non-GUTS patients were to be expected, since all patients of the GUTS received a pulmonary artery catheter (PAC) for the purpose of study treatment and/or measurements, whereas in the non-GUTS patients a PAC was only placed when clinically deemed necessary by the anesthesiologist. In Chapter 2 and 3 also differences were described regarding the use of epidural anesthesia/analgesia and

intraoperatively given RBC. Therefore, in this analysis costs generated by these additional items were accounted for (table 1). Only patients with a planned postoperative ICU-admission, as described in Chapter 3, were analyzed, i.e. 111 GUTS-patients (53 controls, 58 tune-up patients) vs. 161 non-GUTS patients. Patient characteristics and type of surgical procedures performed are described in Chapter 3 (Chapter 3, table 6-9).
The calculation of cumulative costs of both analyses is presented in table 2. Costs were calculated for the period that the GUTS started (1996) and current prices from 2003/2004 were used.

Table 2. Calculations of overall costs for a patient of the control and the tune-up group of the GUTS and of a non-GUTS patient.

GUTS		
	control patient n = 62	tune-up patient n = 65
1996	(ICUds x 1093.08) + ([Wds + 1 – ICUds] x 318.78) + (RBC units x 21.78)	(ICUds + 1 x 1093.08) + ([Wds – ICUds] x 318.78) + (RBC units x 21.78)
2003/ 2004	(ICUds x 1684) + ([Wds + 1 – ICUds] x 476) + (RBC units x 179)	(ICUds + 1 x 1684) + ([Wds – ICUds] x 476) + (RBC units x 179)

GUTS & non-GUTS			
	GUTS Control patient n = 53	GUTS Tune-up patient n = 58	non-GUTS patient n = 161
1996	(ICUds x 1093.08) + [(Wds + 1 – ICUds) x 318.78] + (PAC x 171.30) + (AC x 7.50) + (EC x 69,83) + (RBC units x 21.78)	(ICUds + 1 x 1093.08) + [(Wds – ICUds) x 318.78] + (PAC 171.30) + (AC x 7.50) + (EC 69.83) + (RBC units x 21.78)	(ICUds x 1093.08) + [(Wds + 1 – ICUds) x 318.78] + (PAC x 171.30) + (CVC x 63.17) + (AC x 7.50) + (EC x 69.83) + (RBC units x 21.78)
2003/ 2004	(ICUds x 1684) + [(Wds + 1 – ICUds) x 476] + (PAC x 226) + (AC x 9.30) + (EC x 95.72) + (RBC units x 179)	(ICUds + 1 x 1684) + [(Wds– ICUds) x 476] + (PAC x 226) + (AC x 9.30) + (EC x 95.72) + (RBC units x 179)	(ICUds x 1684) + [(Wds + 1 – ICUds) x 476] + (PAC x 226) + (CVC x 83.70) + (AC x 9.30) + (EC x 95.72) + (RBC units x 179)

ICUds, ICU-days; Wds, days at the ward; PAC, pulmonary artery catheter; CVC, central venous catheter; AC, arterial catheter; EC, epidural catheter; RBC unit, red blood cell concentrate unit. When a PAC, CVC, AC and/or EC were used in individual patients, the abbreviation is numbered 1 for the final calculation of costs in that patient; in a similar way, costs of RBC transfusion are calculated.

Statistical analysis

The Mann-Whitney test and Kruskal-Wallis test were used to compare the patient groups with respect to the cost variables; 5% was used as the level of statistical significance.

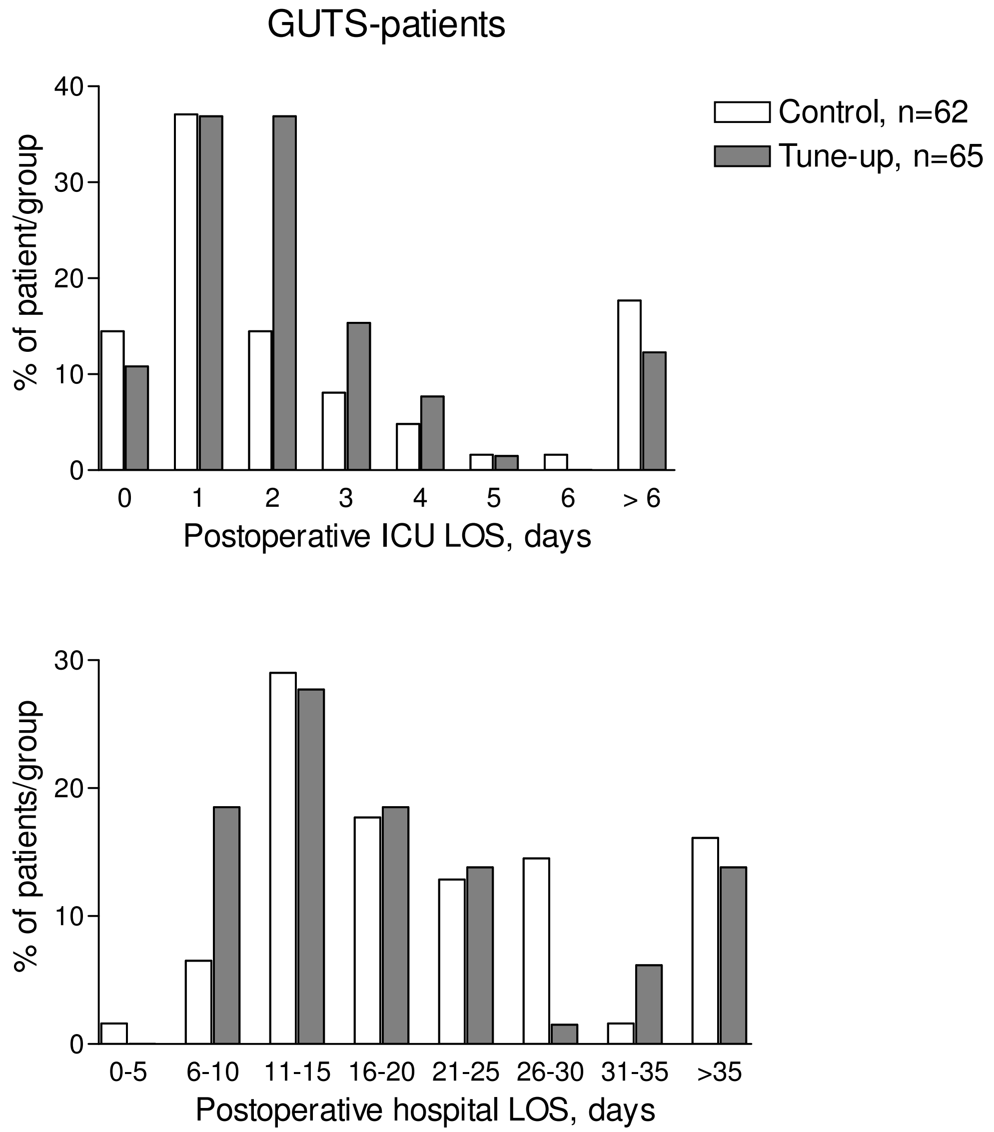

Figure 1. Frequency distribution of ICU LOS (days), including ICU-readmissions, and postoperative hospital LOS, in 127 patients of the GUTS.

Results

Figures 1 and 2 present the frequency distribution of ICU LOS and hospital LOS. Data involved in the calculation of costs in the first analysis are summarized in table 3. This table also contains a summary of data on secondary end points of the main study (Chapter 2).

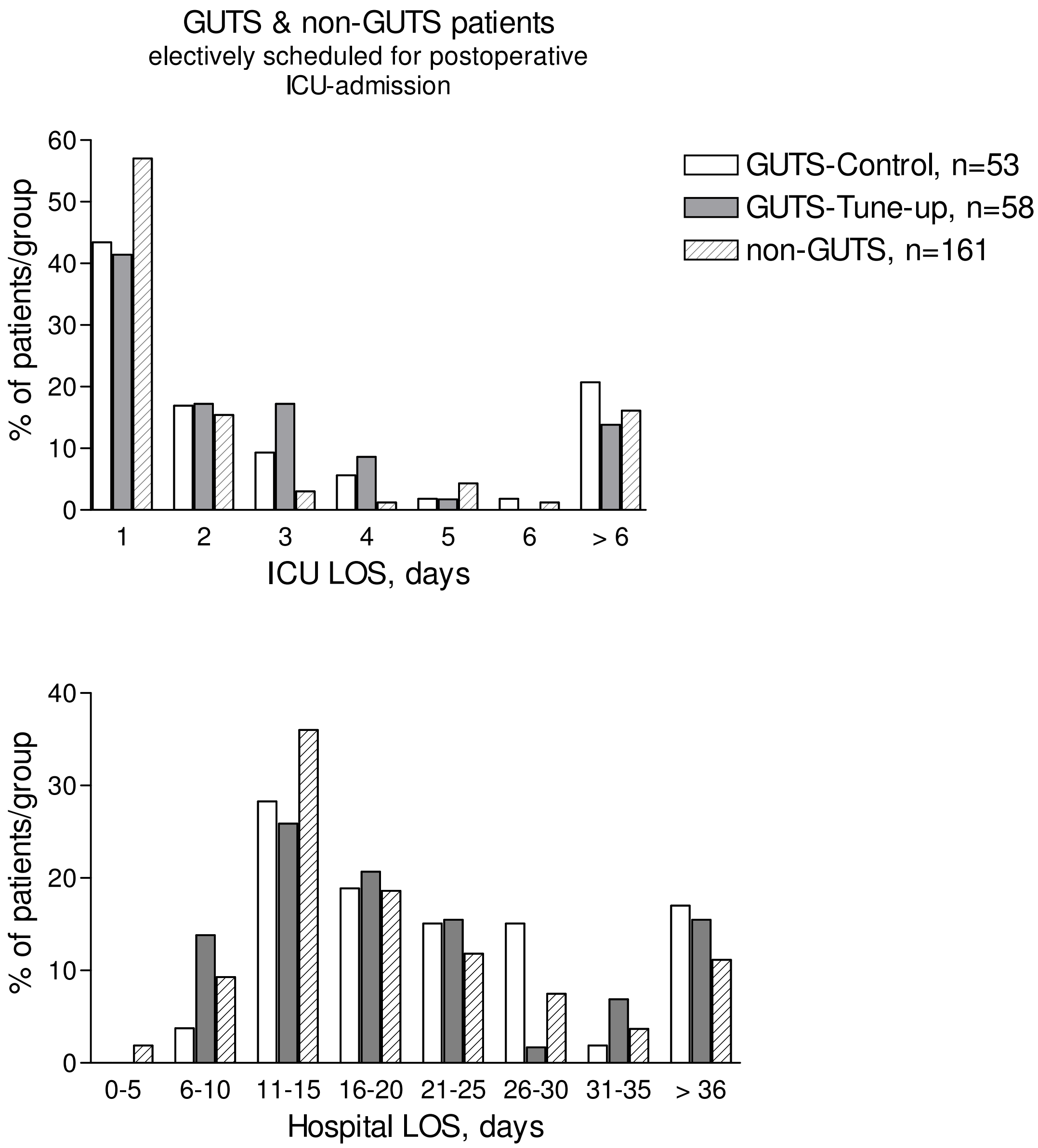

Figure 2. Frequency distribution of postoperative ICU LOS (days), including ICU-readmissions, and hospital LOS of patients of the 111 GUTS (control and tune-up group) and 161 non-GUTS patients.

Table 3. GUTS-patients. Details on issues used for calculation of costs related to preoperative goal-oriented hemodynamic treatment (GOHT, tune-up) at the ICU.

	control n = 62	tune-up n = 65
intraoperative RBC transfusion, all patients:		
- mean (SD)	3.02 (4.31)	1.86 (2.32)
- median ($IQR_{25-75\%}$)	2 (0-4)	1 (0-2.5)
number of patients having RBC transfused (%) if RBC ≥ 1	39 (55)	36 (63)
- mean (SD)	4.79 (4.59)	3.36 (2.15)
- median ($IQR_{25-75\%}$)	4 (2.0-6.0)	2 (0.5-3.5)
via recovery admitted to the ward, number of patients (%)	9 (15)	7 (11)
postoperative ICU LOS, readmissions included, days		
- mean (SD)	3.8 (6.2)	3.3 (4.8)
- median ($IQR_{25-75\%}$)	1 (1-4)	2 (1-4)
postoperative hospital LOS (days), ICU-days included		
- mean (SD)	24.0 (16.1)	24.1 (25.7)
- median ($IQR_{25-75\%}$)	19 (14.0-29.25)	17 (11-23)
ICU readmissions, number of patients		
- first readmission (%)	4 (6.5)	9 (13.8)
- second readmission	0	0
discharge location		
- home	53 (85.5)	62 (95.4)
- nursing home	4 (6.5)	1 (1.5)
- other hospital	4 (6.5)	0 (0)
- hospital mortality	1 (1.6)	2 (3.1)

GUTS, Groningen University Tune-up Study; GOHT, goal oriented hemodynamic treatment; ICU, intensive care unit; RBC, red blood cell concentrate; LOS, length of stay.

Results of overall costs are presented in table 4. We found no statistically significant differences in mean costs/patient between controls and tune-up patients. Ward-related costs tended to be lower in the tune-up group, but ICU-costs were significantly higher in this group. In this model the significantly higher overall ICU-costs in the tune-up group surpass the cost savings achieved at the ward, counterbalancing overall costs at similar levels (table 4).
Data of anesthesiology-related devices and procedures of the second analysis are summarized in table 5. Additional information on RBC-transfusion, postoperative ICU LOS, hospital LOS, ICU-readmissions, discharge location and mortality are also to be found in this table. Costs of single items used for the final calculation and cumulative costs are depicted in table 6. Overall costs in the control and the tune-up patients of the GUTS were higher when compared to costs in the non-GUTS patients (table 6); according to prices in 2003 this difference reached significance. In 1996 the mean difference expressed as costs/patient of a non-GUTS patient was 2,026 and 2,385 Euro compared to a control and a tune-up patient of the GUTS, respectively. Calculated for 2003 these numbers increased to 3,195 and 3,506 Euro/patient, respectively.

Table 4. GUTS patients. Costs are calculated for stay on the ward, stay at the ICU and intraoperative RBC-transfusion; preoperative treatment at the ward (control group) vs. preoperative treatment at the ICU (tune-up group).

costs/patient (euros)	1996			2003/4		
	control n = 62	tune-up n = 65	p	control n = 62	tune-up n = 65	p
ward						
- mean	6,746	6,636		10,073	9,908	
- median	5,579	4,463	0.068	8,330	6,664	0.056
ICU						
- mean	4,197	4,642		6,464	7,151	
- median	1,093	3,280	< 0.001	1,684	5,052	<0.001
RBC						
- mean	66	40		540	333	
- median	44	22	0.196	358	179	0.196
cumulative costs/patient						
- mean	11,008	11,318		17,077	17,392	
- median	7,947	7,606	0.534	12,424	11,460	0.520

GUTS, Groningen University Tune-Up Study; ICU, intensive care unit; RBC, red blood cell concentrate.

Table 5. GUTS vs. non-GUTS patients. Data on perioperative epidural anesthesia and analgesia, invasive hemodynamic monitoring and RBC-transfusion. Data of epidural anesthesia/analgesia, hemodynamic monitoring and transfusion were available in 157 (97.5%) non-GUTS patients. ICU-readmissions were included for calculation of ICU LOS related costs.

	control n = 53	tune-up n = 58	non-GUTS n = 161
epidural catheter, number of patients (%)	47 (88.7)	51 (87.9)	125 (78.6)
invasive hemodynamic monitoring number of patient with			
- arterial canula (%)	53 (100)	58 (100)	151 (93.8)
- CVP-line (%)	-	-	113 (70.2)
- PAC-introducer (%)	-	-	12 (7.5)
- PAC, complete (%)	53 (100)	58 (100)	28 (17.4)
RBC transfusion			
- mean, all patients (SD)	3.4 (4.5)	2.0 (2.4)	2.7 (3.0)
- number of patients & RBC-transfusion (%)	37 (69.8)	34 (58.6)	105 (65.2)
- transfused mean, if RBC ≥ 1 (SD)	4.8 (4.7)	3.4 (2.2)	3.9 (2.9)
postoperative ICU LOS, days			
- mean (SD)	4.4 (6.5)	3.6 (4.9)	3.5 (5.4)
- median ($IQR_{25-75\%}$)	2.0 (0-4)	2.0 (1-3)	1.0 (0-2)
postoperative hospital LOS, days			
- mean (SD)	25.0 (25.8)	25.7 (26.8)	20.7 (14.7)
- median ($IQR_{25-75\%}$)	20 (12.5-27.5)	17.5 (10.6-24.4)	16.0 (10.3-21.8)
ICU-readmissions, number of patients			
- first readmission (%)	4 (7.5)	9 (15.5)	14 (8.7)
- second readmission (%)	-	-	2 (1.2)
discharge location, number of patients			
- home (%)	45 (84.9)	55 (94.8)	140 (87.0)
- nursing home (%)	4 (7.5)	1 (1.7)	4 (2.5)
- other hospital (%)	3 (5.7)	0 (0)	6 (3.7)
- mortality (%)	1 (1.9)	2 (3.4)	11 (6.8)

GUTS, Groningen University Tune-Up Study; ICU, intensive care unit; RBC, red blood cell concentrate; CVP, central venous pressure; PAC, pulmonary artery catheter.

Table 6. Costs of GUTS patients (control and tune-up group) vs. non-GUTS patients. All patients were preoperatively planned for ICU-admission after surgery.

costs/patient (euros)	1996				2003			
	control n = 53	tune-up n = 58	non-GUTS n = 161	p	control n = 53	tune-up n = 58	non-GUTS n = 161	p
Preoperative day	319	1,093	319		476	1,684	476	
EC								
- mean	62	61	54		85	84	74	
IV-monitoring								
- mean	179	179	88		237	237	115	
RBC								
- mean	74	44	52		605	361	475	
postoperative ICU								
- mean	4,848	3,978	3,837		7,467	6,126	6,259	
- median	2,187	2,187	1,093	0.067	3,368	3,368	1,684	0.067
postoperative ward								
- mean	6,556	7,041	7,533		9,789	10,513	8,186	
- median	5,419	4,941	4,144	0.057	8,092	7.378	6,188	0.057
cumulative								
- mean	12,037	12,396	10,010		18,659	19,006	15,498	
- median	9,404	8,789	7,273	0.008	14,209	13,221	11,286	0.013
- $IQR_{25\%}$	6,442	6,544	5,611		10,022	10,116	8,585	
- $IQR_{75\%}$	15,214	8,789	11,254		23,847	19,711	17,360	

GUTS, Groningen Univeristy Tune-up Study; ICU, intensive care unit; EC, epidural catheter; IV, intravascular; RBC, red blood cell concentrate

Discussion

ICU LOS and hospital LOS, defined as secondary end points of the GUTS, reflect the severity of the primary end points and are the main determinants of costs. Preoperative tune-up at the ICU did not reduce overall costs in a model in which the emphasis is laid on LOS in the ICU and the hospital. At first glance it seems that costs are saved regarding LOS at the ward, but at the same time extra costs of tune-up and ICU-readmission offset these savings. It should be realized that the result of this nearly zero cost balance is flattered by the fact that tune-up patients in many aspects seemed to be in a clinically more favorable condition. Confounding patient factors and blood loss appeared to explain differences in outcome, and not tune-up as such (Chapter 2). If both groups would have matched better it could be hypothesized that the minor difference in costs/patient in favor of the control group would have been larger. In addition, the second analysis, when the GUTS groups were compared to the non-GUTS group, the perspective is shown that significantly lower costs already were achieved in this model applied to the conditions of 1996 and also could have become lower in 2003. From this perspective it seems appropriate not to implement tune-up as a regular procedure of perioperative care in patients described as high-risk according to the definitions used till now.

When ICU LOS or hospital LOS are not reduced by tune-up, in our institution the related additional costs may be an extra argument not to implement such a therapy in high-risk surgical patients, according to the protocol of the GUTS. On the other hand, if a selection of these patients may still benefit clinically from tune-up, it is questionable whether to confine tune-up to the ICU. Facilities of a high dependency unit or recovery room could also have been used for tune-up and also the timing of tune-up can probably be restricted to a few hours.[5] This latter possibility would have resulted in considerable cost savings of the tune-up procedure.
Limitations of our study have to be considered. In Chapter 2 (Results, table 2) we described that 14 patients had to be excluded, obscuring an actual intention to treat cost-analysis. It has to be expected that the actual difference in costs would have become enlarged because of these patients, who had been incorrectly enrolled in the GUTS. Another problem is that a few patients were discharged to another hospital. From a macroeconomic point of view these costs should have been included in overall costs, as they influence overall results. Similar considerations have to be made regarding hospital readmissions related to late postoperative complications of the primary surgical procedure.
The calculations may seem crude as it would have been more correct if a differentiation of all costs involved could have been presented (medication, diagnostic and therapeutic additional postoperative interventions at the ICU and the ward, including surgical reinterventions). We also discarded the period of the day when patients were discharged from the ICU to the ward, where others calculated ICU-costs in Euro/hr of ICU LOS and ward LOS.[8] When ICU-costs are dependent on mechanical ventilation, we should have separately differentiated the ICU-costs for patients on and off the ventilator. We decided to calculate actual costs, therefore the calculations also do not take into account the survival status of the patient at the end of the hospital stay.
This study was performed in a tertiary hospital. It has also been shown that in the Netherlands large differences exist between hospitals regarding overall costs of one day stay at the ICU or at the ward.[13]
Therefore, the conclusions of this study have to be restricted to our hospital.
Taheri et al. showed that by a reduction of one hospital day cost savings are limited, since the costs of the last days of hospital admission cover a small proportion of overall costs.[14] This phenomenon specifically considers patients undergoing major surgery and being admitted to the hospital > 15 days.
Preoperative-ICU admission in abdominal aortic surgery has been shown to increase costs specifically by increase in ICU LOS and hospital LOS.[15] More recently specific perioperative management has been developed on (major) vascular surgical procedures, without preoperative ICU-admission, to achieve a ‘short track’.[16,17] Reducing LOS by 33% resulted in major cost savings.[17] Reducing hospital LOS by ‘short track’ also has been described for other high-risk surgical procedures.[18,19] However, rapid discharge from the hospital may increase costs in out of hospital health care.
We were not able to reduce ICU LOS and hospital LOS by GOHT. At the same time GOHT-related costs appeared to be significantly higher when compared to a mixed group of high-risk patients in our hospital who had not been exposed to a GOHT protocol. Moreover, others have shown that perioperative management, directed at accelerating early postoperative recovery by other strategies than GOHT, could significantly reduce ICU LOS and hospital LOS. High-risk patients who evidently benefit from GOHT still have to be defined. Given the absence of clear criteria to identify these patients we conclude that in our current practice GOHT does not reduce costs.

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